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STUDIES IN THE NOMENCLATURE AND CLASSIFICATION OF THE BACTERIA

V. SUBDIVISIONS AND GENERA OF THE SPIRILLACEAE, AND NITROBACTERIACEAE

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Family III. **Spirillaceae** Migula, 1894, p. 237

Synonyms:

Spirillina Perty, 1852, p. 179
Spirillineae Cohn, *in ed.* Rabenhorst, 1865, p. 70
Spirobacteria Cohn, 1872, p. 180
Vibrioneae Trevisan, 1879, p. 139
Spirobacteriaceae Hueppe, 1886, p. 143
Spirilleae De Toni and Trevisan, 1889, p. 1006

Cells elongate, not spherical, bent in the form of a spiral or a segment of a spiral. Usually motile by means of polar flagella. Without sulfur granules or bacteriopurpurin.

Perty (1852) subdivided the *Spirillina* into the genera *Spirillum* and *Spirochaeta.*

Cohn (1872) likewise divided the tribe *Spirobacteria* into *Spirillum* with cells rigid, relatively short, and *Spirochaete,* with cells flexuous and relatively long. In 1875 Cohn described the additional spiral genus *Myconostoc* in which the spiral cells occurred embedded in a mass of gelatin, and included *Vibrio, Spirillum, Spirochaete* and *Myconostoc* in the algal tribe *Nematogenae.* The genera may be separated by the following key.

Key to genera of spiral Nematogenae Cohn

A. Cells not united by gelatin into families.
  1. Filaments short, sinuous.....*Vibrio*
  2. Filaments short, spiral, rigid.....*Spirillum*
  3. Filament long, spiral, flexible.....*Spirochaete*
B. Cells united into a glairy family.....*Myconostoc*

Zopf (1885, p. 50) differentiated *Vibrio* from *Spirillum* because the former was said to produce spores.

Hueppe (1886) further subdivided these forms on a similar basis as follows:

1. Without endospores.....*Spirochaete*
2. With endospores.
   a. Without change of cell form upon spore production. *Spirillum*
   b. With change of form upon spore production.....*Vibrio*

Winogradsky (1888, p. 105) removed the spirals containing sulphur to a new genus and gave them the name *Thiospirillum.*

Schroeter (1886) differentiates by the following key.

1. Cells stiff (not flexuous). With endogenous spores...*Spirillum*
2. Spirals flexuous.
   a. Cells known only in the form of a long flexuous spiral. Spores not known.....*Spirochaete*
   b. Cells usually only one half spiral, later growing to spirals. Arthrospores?.....*Microspira*

Migula (1894 p. 237) separated the genera of the *Spirillaceae* as follows:

I. Cells stiff, not flexuous.
   a. Cells non-motile.....*Spirosoma*
   b. Cells motile, with flagella.
      1. Cells with 1, rarely 2 or 3 polar flagella.....*Microspira*
      2. Cells with tuft of polar flagella.....*Spirillum*
II. Cells flexuous.....*Spirochaete*

Lehmann and Neumann (1896) subdivide the *Spirillaceae* as follows:

I. Cells short, slightly bent, with one or two polar flagella...*Vibrio*
II. Cells long, spirally bent, rigid, usually with a tuft of polar flagella.....*Spirillum*
III. Cells flexible, long, spiral, coiled filaments, flagella unknown. *Spirochaeta*

Blanchard (1906, p. 1) removed the genus *Spirochaeta* to the protozoa, and separated the bacterial genera as follows under the heading *Spirobacteria.*

A. Non motile ..... *Spirosoma*
B. Motile
1. Cells rigid, forming a segment of a circle or united into spirals, 1, 2 or 3 polar flagella ..... *Vibrio*
2. Cells definitely spiral:
a. With endogenous spores. Flagella not polar. *Spirobacillus*
b. With or without endogenous spores. Flagella polar *Spirillum*

The following generic names have been proposed for spiral organisms.

Spirillum Ehrenberg, 1830, p. 38
Myconostoc Cohn, 1875, p. 183
Pacinia Trevisan, 1885, p. 83
Microspira Schroeter, 1886, p. 168
Pseudospira De Toni and Trevisan, 1889, p. 1018
Euspirillum De Toni and Trevisan, 1889, p. 1009
Euspirosoma Migula, 1900, p. 955
Liquidovibrio Jensen, 1909, p. 333
Solidovibrio Jensen, 1909, p. 333
Paraspirillum Dobell, 1911, p. 94
Vibrio Mueller, 1773, p. 39
Spirodiscus Ehrenberg, 1838
Spiromonas Perty, 1852, p. 171
Spirulina Hueppe, 1886, p. 146
not *Spirulina* Turpin, 1827
not *Spirulina* Cohn, 1853
Spirobacillus Metschnikoff, 1889, p. 61
Streptospirillum Billet, 1890, p. 24
Spirosoma Migula, 1894, p. 237
Sporospirillum Jensen, 1909, p. 340

The generic name *Spirulina* is invalid because of prior use for another genus of plants.

The species of the following genera cannot be identified from the description. *Myconostoc, Spirodiscus, Spiromonas, Streptospirillum, Spirobacillus, Sporospirillum.*

The following are subgeneric terms: *Euspirillum, Euspirosoma, Pseudospira.*

The following genera are probably not invalid for any of the preceding reasons.

Liquidovibrio, Microspira, Pacinia, Paraspirillium, Solidovibrio, Spirillum, Spirosoma, Vibrio.

The following key will serve to differentiate the genera which may be recognized at present.

Key to genera of Spirillaceae

A. Cells not larger at center, not tapering.
   1. Cells usually short, only a segment of a spiral. One or rarely two or three polar flagella.....Genus 1. *Vibrio*
   2. Cells longer, usually with a tuft of polar flagella. Genus 2. *Spirillum*

B. Cells enlarged at center and tapering.....Genus 3. *Paraspirillum*

Genus 1. **Vibrio** Mueller, 1786 p. 39 emended

Synonyms

Pacinia Trevisan, 1885, p. 83
Pseudospira De Toni and Trevisan, 1889, p. 1018
Microspira Schroeter, 1886, p. 168
Liquidovibrio Jensen, 1909, p. 333
Solidovibrio Jensen, 1909, p. 333

Short, bent rods, sometimes almost straight. Motile by means of a single (rarely 2 or 3) polar flagellum. Aërobic, and facultative. Grow well on ordinary media. Frequently liquefy gelatin. Not enlarged near center. No spores. Usually gram negative.

The type species is *Vibrio cholerae*. The generic name *Vibrio* has been used in several senses by different writers. Most of the species included in this genus by writers before the time of Cohn are now definitely placed in other genera or cannot be identified. Pacini (1851) used the designation *Vibrioni of cholera*, though it is not certain that he actually saw the organism causing the disease.

The *Vibrio* of Müller was any very simple, "terete, elongate worm." Ehrenberg (1838) defined the genus to include straight flexuous rods. Cohn (1872, p. 178) emended the genus to include organisms characterized by a wavy motion of the fila-

ments, the rotation of which gives the appearance of sinuous motion, this character indicating transition to the spiral bacteria. Zopf (1885, p. 61) definitely designates the genus as spiral. Some authors retained the older idea of the genus, and introduced new generic names as *Pacinia* and *Microspira*, others used the generic name *Vibrio* for short spirals. The latter conception is held by Loeffler, Fischer, Lehmann and E. F. Smith and is the one adopted here.

Vuillemin (1913, p. 518) concludes that *Vibrio* used as a generic name should be suppressed because of its varied meanings. He would use the generic name *Microspira*. However, if *Vibrio* should be abandoned, *Pacinia* Trevisan would definitely have priority.

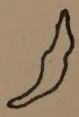
Genus 2. **Spirillum** Ehrenberg 1830, p. 38 emended, Migula, 1894, p. 237.

Synonym:

Spirosoma Migula, 1894, p. 237

Cells definitely spiral, not enlarged at center, motile by means of 5 to 20 polar flagella, or non-motile. Not readily cultivated in ordinary culture media.

The type species is *Spirillum undula* (Müller) Ehrenberg.



Genus 3. **Paraspirillum** Dobell 1911, p. 99

Cells spiral or S shaped, like spirilla, variable in thickness, with a well marked thickening toward middle of the body, and tapering toward the ends, a much elongated and spirally twisted spindle. Motile by means of flagella.

The type species is *Paraspirillum vejdovskii* Dobell.

Family IV. **Nitrobacteriaceae** Fam. nov.

Cells spherical or rod shaped, motile or non-motile, not growing on ordinary laboratory media in the presence of organic matter. Securing growth energy primarily by the oxidation of ammonia to nitrites or of nitrites to nitrates.

The genera may be differentiated by the following key:

Key to the genera of Nitrobacteriaceae

A. Cells rod shaped.
1. Oxidizing ammonia to nitrous acid. Motile. Genus 1. *Nitrosomonas*
2. Oxidizing nitrous acid to nitric acid.....Genus 2. *Nitrobacter*
B. Cells spherical.....Genus 3. *Nitrosococcus*

Genus 1. **Nitrosomonas** Winogradsky, 1892, p. 127

Synonym:
Nitromonas Winogradsky

Cells rod shaped. Motile. Not growing readily on organic media. Oxidizing ammonia to nitrates.

The type species is *Nitrosomonas europoea* Winogradsky.

Genus 2. **Nitrobacter** Winogradsky, 1892, p. 127

Cells rod shaped, non-motile, not growing readily on organic media, oxidizing nitrates to nitrates.

Winogradsky named no species, although one was described. It may be termed *Nitrobacter winogradski* and regarded as the type species.

Genus 3. **Nitrosococcus** Winogradsky, 1892, p. 127

Cells spherical. Not growing readily on organic laboratory media. Oxidizes ammonia to nitrites.

Winogradsky termed the single species "les microbes nitreux de nouveau monde" but without a species name. It may be termed *Nitrosococcus americanus* and regarded as the type.

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